Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 25C (2017) 2465–2476

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2016 Shanghai. 10-15 July 2016

A Combined Activity Nodes Choice and Trip-chain Based User Equilibrium Traffic Assignment Model

Chung-Yung Wang [a]*, Shou-Ren Hu [b], Chih-Peng Chu [c]

[a] *National Defense University, 70, Sec. 2, Central North Road, Peitou District, Taipei City 11258, Taiwan*
[b] *National Cheng Kung University, 1, University Rd., East District, Tainan City 70101, Taiwan*
[c] *National Dong Hwa University, 1, Sec. 2, Da Hsueh Rd., Shoufeng, Hualien 97401, Taiwan*

Abstract

Analysis of traveler behaviors generally includes multiple activities en route among different origin and destination pairs, which are presented as trip chaining. These activities can be decomposed as a single trip into a chain of a primary activity and secondary activities. Because the sequence of different activities is associated with different travel cost during a trip-chain, and some of secondary activities are not necessary to go to the specific nodes to complete these activities. That is, the trip-chain based travelers' trip-chain route choice behaviors and secondary activity nodes choice should be considered simultaneously. In this study, a combined activity nodes choice and trip-chain based user equilibrium traffic assignment model is formulated. A new solution algorithm is also developed, and the model performance was verified using the modified UTown test network. The numerical analysis result has an implication for urban traffic management and sustainable mobility.

Keywords: *trip-chain, route choice, secondary activity nodes choice, traffic assignment*

1. Introduction

Analysis of traveler behavior generally includes multiple activities en route among different origin and destination (OD) pairs, which are presented as trip-chaining. The trip-chains of multiple activities can be divided

* Corresponding author. Tel.: +886-937406598; fax: +886-2-28958917
E-mail address: stellar@ms35.url.com.tw

2352-1465
10.1016/j.trpro.2017.05.271

into primary and secondary activities. The former refers to the primary purpose for which trips are initiated and specific travel behavior between OD pairs is based on; the latter indicates activities that are performed during the completion of primary activities. In general, the secondary activities in the trip-chain influence travelers trip-chain route choice behaviors. However, for the same function of secondary activity nodes choice, it also would be influenced by travelers trip-chain route choice behaviors. For example, the actual home-work trips often involve several secondary activities, such as buying a breakfast at the coffee shop, making a deposit at the bank. These activities decompose a single home-work trip into a chain of secondary activities such as: home→coffee shop→bank→work. Due to the sequence of different activities is associated with different travel cost during a trip-chain, and the "coffee shop" and "bank" are not necessary to go to the specific coffee store or bank to complete these activities. There are many coffee shops and banks could be chosen to buy a breakfast and to make a deposit. That is, the trip-chain based travelers trip-chain route choice behavior and secondary activity nodes choice should be considered simultaneously. The analysis of trip-chain travel demands has been ignored in the conventional trip-chain based traffic assignment models. Therefore, it is necessary to develop a combined activity nodes choice and trip-chain based user equilibrium traffic assignment model to reflect the true transportation demands. In this study, a combined activity nodes choice and trip-chain based user equilibrium traffic assignment model is formulated. A new solution algorithm is also developed in this study. The validity of this study was verified using the modified Utown network (U.S. Department of Transportation, 1986). The numerical study result has an implication for urban traffic management and sustainable mobility.

2. Literature review

Hägerstrand (1970) was the first researcher to discuss the trip-chain phenomenon and proposed the activity-based travel behavior theory. Srinivasan (1988) presented a definition of trip-chains as a series of activities scheduled in time and space, chaining together a work trip and one or more non-work trips. Primerano et al. (2000) observed that the trip-chains of multiple activities can be divided into primary and secondary activities. The former refers to the primary purpose for which trips are initiated and specific travel behavior between an OD pair is based on; the latter indicates activities that are performed during the completion of primary activities. In many empirical studies of traveler behaviors analysis from different social economic survey data also pointed out, such as Hensher and Reyes (2000), McGuckin et al. (2005), Morency and Valiquette (2010), Currie and Delbosc (2011), Zhao et al. (2012), the trip-chain phenomenon exists in the travel choice behavior of road users.

Based on the assumption that individuals display trip-chaining behavior, Lam and Yin [9] proposed a dynamic user equilibrium activity/route choices model. Through this model, activity participation can be considered in time-dependent route choice behaviors of travelers. Maruyama and Harata (2005) argued that if trip-chains were processed as single independent trips, the connections among trips could not be seen, which would lead to discrepancies in the forecasting of travel demands. To overcome this problem, they adopted the trip-chaining behavior of road users under static user equilibrium principle. Given an established order of activities and the presumption that they must be completed in the fixed trip-chain order, they developed two-stage combined models of trip-chaining (including a combined trip distribution and traffic assignment model and a combined modal split and assignment model), and solved the models using a traditional algorithm of linear approximation.

Maruyama and Harata (2006) proposed a trip-chain based network equilibrium model. The model was grounded on the traffic assignment model with variable demand proposed by Beckmann et al. (1956), which considered the trip-chaining patterns of road users in which the inverse demand function in the original objective function was modified as a function of trip-chain flow. A constraint of flow conservation in trip-chains was also added, thereby establishing the trip-chain network equilibrium model. Maruyama and Sumalee (2007) proposed that a direct relationship exists between congestion pricing and trip-chaining behavior. They adopted the trip-chain based equilibrium model developed by Maruyama and Harata (2005) to discuss the effectiveness and fairness of cordon-